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AGRICULTURAL MEMORANDUM NO 1080

Temperature - Leaf Number Relations for Winter Barley, 1985/86: the effect of artificially altered daylength and a comparison between soil surface and screen temperatures.

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Summary

Previous experiments have shown the high degree of correlation between main shoot leaf number of winter barley and thermal time from sowing measured in a Stephenson Screen. However the thermal time required between successive leaves is generally greatest between November and February and less at other times of the year. An experiment was performed in 1985/86 which compared the effect of an artificially reduced daylength with natural daylength on plants with the same sowing date. Soil surface as well as screen thermal time was used in relations with leaf number. The reduced as compared to natural daylength between September and November did not appear to have any effect on the rate at which leaves were produced or the final leaf number. The difference between soil surface and screen thermal time seemed to explain a good deal of the slowing down of leaf production in winter.

Experimental Methods

The site and methods were the same as those described in Ag. Memo 1066. The crop was sown on 15 September 1985 in two rows oriented N - S. One row was left to have natural daylength and the other was covered by an aluminium tray from 22.00 to 08.15 BST each day from 17 September to 21 November. A second sowing occurred on 19 October, but no cover treatment was applied to this.

Temperature probes attached to integrators (ΔT Devices Ltd) were placed on the bare soil exposed to natural daylength and the modified daylength. After 8 December one probe was left on bare soil and one was fixed in the screen to log screen temperatures. Alcohol in glass minimum thermometers were placed on the soil surface to compare bare soil minima under the cover and on exposed bare soil.

Probes, integrators and minimum thermometers were interchanged at frequent intervals to reduce systematic errors.

Results

1. Variation in Daylength

Figure 1 shows the variation on daylength and Civil Twilight for the covered and uncovered treatment. At crop emergence the natural daylength was 12 hours, but only 10.8 hours for the covered plants. This difference decreased to zero at the end of October after which both treatments had equal daylength. However, the photoperiodic responses of plants often depend on the duration of the day measured well into the twilight period of evening and morning and so the civil twilight 'daylength' is also shown. The covered treatment did not have a morning twilight period when the change from dark to light was very rapid. On 17 September the difference between the twilight daylengths was 1.7 hours, but this decreased to almost nil at the end of the cover treatment on 21 November.

As well as daylength, the cover treatment changed the rate of change of daylength. At crop emergence the values were -0.074 hrs/d (natural) and -0.0367 hrs/d (cover) which is important in view of the published correlations between thermal time per leaf and rate of change of daylength.

2. Leaf Number and Thermal Time

Figure 2 shows leaf number plotted against screen thermal time (= the sum of daily mean temperatures above 0°C) from 15 September. One line is for a covered plant, one for an uncovered, and one for a plant sown on 19 October. As in earlier experiments it is possible to represent the early sowings by three lines with the period from mid November to the end of February having the largest number of day degrees per leaf, see Table 1. In these graphs the central section is not so well marked as in previous years. This is probably due to a very cold February when only 8.3 day degrees above 0°C were recorded. Because of this only ~2.5 leaves grew in the winter rather than the more usual ~3. In addition the plants grew slower than normal from emergence and required 115°C d per leaf (mean value for 4 plants, covered and uncovered) compared to 90 (±5) °C d per leaf, which is a mean value derived from 10 plants in previous years. This may have been due to a rather cloddy seedbed and long dry spell after sowing which caused a poor and uneven crop emergence. The net result of all this is a shorter central section and a smaller change in slope in November.

Figure 2 shows that the covered plant grew in a similar way to the uncovered. The thermal times per leaf were similar in the autumn and winter, and the change of slope happened in November for both plants. There is no indication that it occurred earlier for the covered plant. The covered plant grew faster in spring probably because it ended up with 15 rather than 14 leaves.

In Figure 3 the leaf number of two other covered and uncovered plants is plotted against screen thermal time. The graphs are similar to Figure 2, though the uncovered plant grew so slowly in autumn (after an initial rapid start), that it is very dubious if two lines are needed to represent autumn and winter growth.

Effect of the Cover

As well as affecting daylength it became clear that the cover altered other aspects of the environment as well. Obviously, wind speed was reduced to zero under the cover, and it was warmer and possibly more humid as well. The degree day total as measured by the probes and loggers between 24 September and 21 November was 548°C d for the covered plants and 526°C d for uncovered. The average bare soil minima were 5.8°C (cover) and 4.7°C (not cover). The monitored plants produced 5.2, 4.7 leaves (covered) and 4.6, 3.6 (uncovered) in that time with leaf rates of 105.9, 116.5 °Cd/l (using cover temperatures with cover plants) and 113.1, 144.2 °Cd/l (bare soil temperatures with noncovered plants). It is suggested that the 144.2 °Cd/l plant is not typical and leaf growth was related to the local environment temperatures, rather than the rate of change of daylength as suggested by Kirby et al (1982) whose results would imply a reduction in leaf rate of about 17 °Cd/l for the covered treatment.

The two monitored cover plants produced 14.5 leaves (average) as against 13.5 for the natural daylength. This does not agree with Jones and Allen (1986) who suggest that shorter days produce fewer leaves.

TABLE 1

Leaf rates (°C d/leaf), using screen values of thermal time for the three linear sections compared with average values.

Seed sown on 15 September 1985.

	Section	1 (Autumn)	2 (Winter)	3 (Spring)	Final leaf Number
Covered		113.6	136.5	86.7	14
		106.2	126.7	70.8	15
	Mean	109.9	131.6	78.8	
Uncovered		126.7	143.4	87.4	13
		112.9	127.8	82.5	14
	Mean	119.8	135.6	82.5	
Average (from previous experiments)		89.6 ± 5	131.1 ± 15	75.5 ± 11	

Bare Soil Temperatures

The accumulated temperature logged by an unscreened probe laid onto bare soil is compared with thermal time in the screen in Figure 4. From September to November both positions had very similar totals and by mid November the bare soil position was 5.4°C days greater. From then until early March the screen position recorded more day degrees and by 2 March the soil position was 70.8°C days behind the screen position. This difference subsequently decreased to about 20°C d by early June. The similarity of Figures 4, 2 and 3 is striking and supports the idea that the surface soil and also the plants in it are cooler than at screen level from November to February. This was suggested from climatological radiation conditions in Ag. Memo 1066.

Thermal Times in the Screen

Thermal time was logged in the screen by a probe from 8 December 1985 to 23 June 1986. Table 2 shows a comparison between day degree values obtained by summing daily mean temperatures and those found using the logger. During periods when the temperature fluctuated about 0°C the logger recorded greater totals. Between 8 December and 31 March the logger recorded 30.8°C days more than the simple method. By the end of June the logger was 3.6°C days ahead of the simple method.

TABLE 2

Comparison of day degrees (°C days) observed by a logger (ΔT) with the sum of daily mean temperatures obtained by averaging 24 hour values of maximum and minimum temperature in the screen (Tt).

Period : 8 12 85 to 23 6 86

	Tt	ΔT	Difference (ΔT - Tt)	Cumulative difference
8/12 - 31/12	107.8	115.6	7.8	7.8
1/1 - 31/1	86.3	94.9	8.6	16.4
1/2 - 28/2	8.3	13.3	5	21.4
1/3 - 31/3	132.1	141.5	9.4	30.8
1/4 - 30/4	154.3	140.1	-14.2	16.6
1/5 - 2/6	369.9	359.8	-10.1	6.5
3/6 - 23/6	271.1	268.2	- 2.9	3.6

Conclusions

1. Leaf Number, thermal time relations for single plants were similar to those found in previous years, and for September sowings three straight lines represented the data better than one line.

2. Within the limits imposed by poor and uneven plant establishment an artificially reduced daylength did not affect the timing of the changes in slope of the leaf number/thermal time lines.

3. Accumulations of temperature were less at the soil surface between November and February which is suggested as the reason why the plants apparently need more thermal time at screen level during the winter. It is not suggested that a soil surface temperature measurement by an unscreened probe represents exactly the temperature to which the plant is responding. Also for April onwards the growing point rises above the soil and as the leaf cover increases then a soil surface temperature measurement becomes less representative.

4. The four plants which were monitored all differed in their thermal time requirements per leaf. However, Table 1 shows that the relative order of the four plants remained the same throughout the period of leaf growth, ie if a plant started off fast then it remained fast. It is suggested that this could be due to seedling 'vigour', conditions in the seedbed, or both. In this and in previous trials it has been noticed that leaf one is produced faster than later leaves so that the first one or two points on the graphs of leaf number/thermal time rarely lie on the line. An extreme example is in Figure 3 (uncovered). This plant produced leaf one rapidly, but then slowed down. In fact this plant remained small which suggests that soil conditions (compaction, nutrient status) can affect plant growth at an early stage and from which it subsequently cannot recover.

Table 1 also shows that there was a strong positive correlation between final leaf number and the speed with which the plants grew: faster plants had more leaves. Since all the leaf initials are produced during the first few weeks of growth it follows that early growth rate could indeed have some effect on total leaf number.

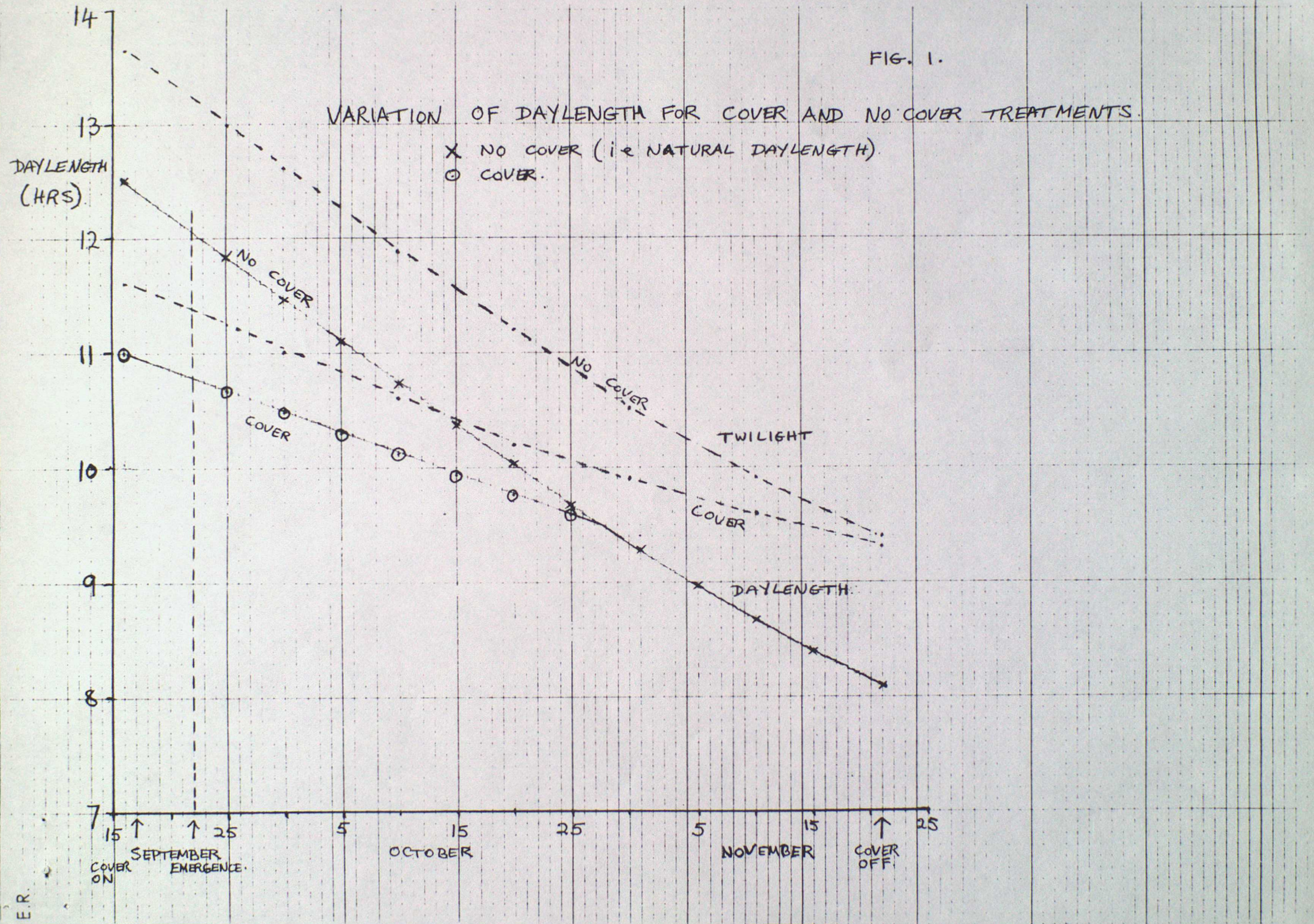
Meteorological Office, Harrogate
October 1986

REFERENCES

Jones, J L and Allen, E J (1986) Development in Barley. J Agric Sci, Camb, 107, 187-213.

Kirby, E J M., Appleyard, M and Fellowes, G (1982) Effect of sowing date on the temperature response of leaf emergence and leaf size in barley. Plant, Cell and Environment, 5, 477-484.

FIG. 1.


VARIATION OF DAYLENGTH FOR COVER AND NO COVER TREATMENTS.
X NO COVER (i.e NATURAL DAYLENGTH)
⊙ COVER.
DAYLENGTH (HRS)
14
13
12
11
10
9
8
7
No Cover
No Cover
TWILIGHT
Cover
Cover
DAYLENGTH
15
25
5
15
25
5
15
25
SEPTEMBER
OCTOBER
NOVEMBER
COVER ON
EMERGENCE.
COVER OFF.

E.R.

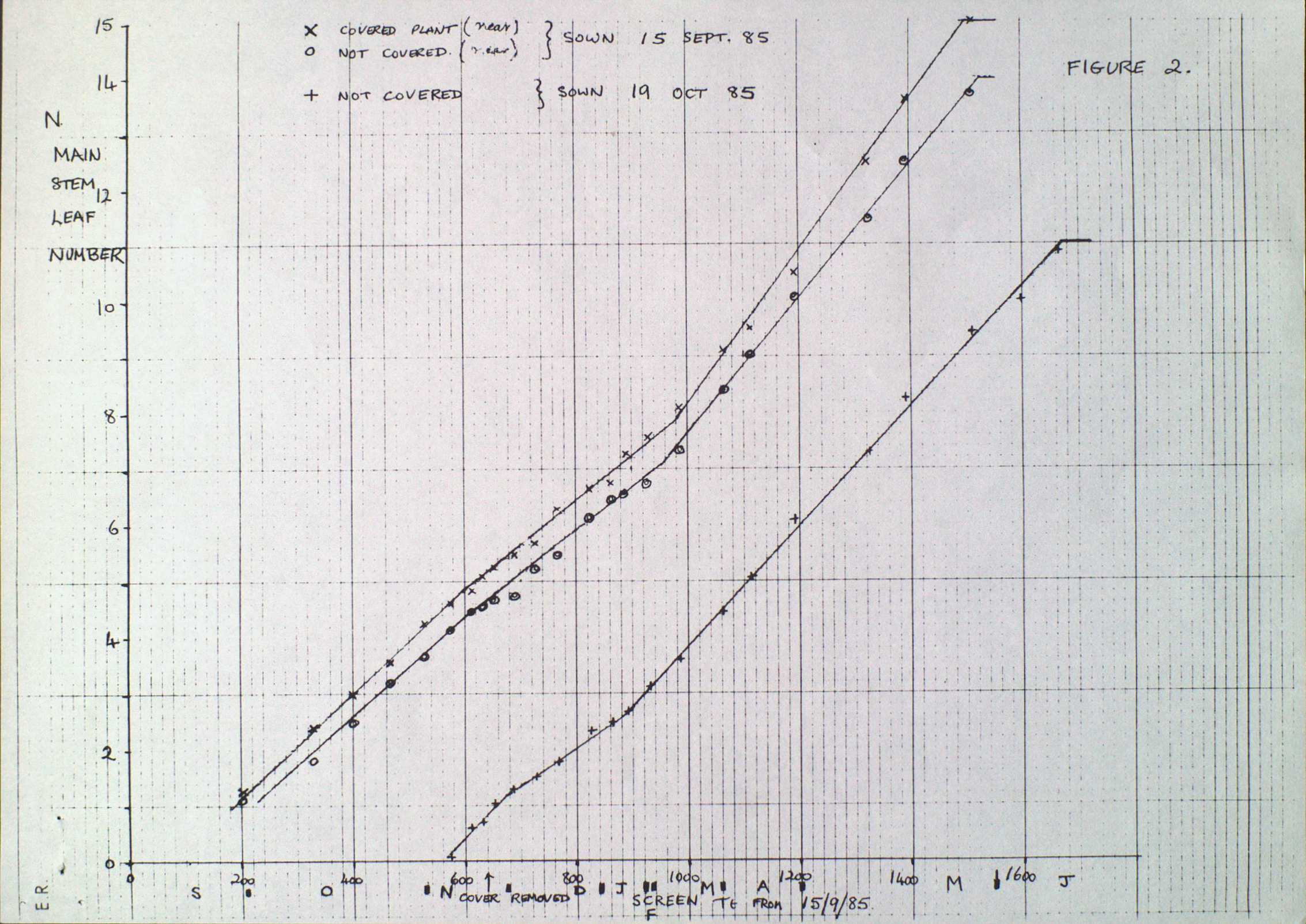
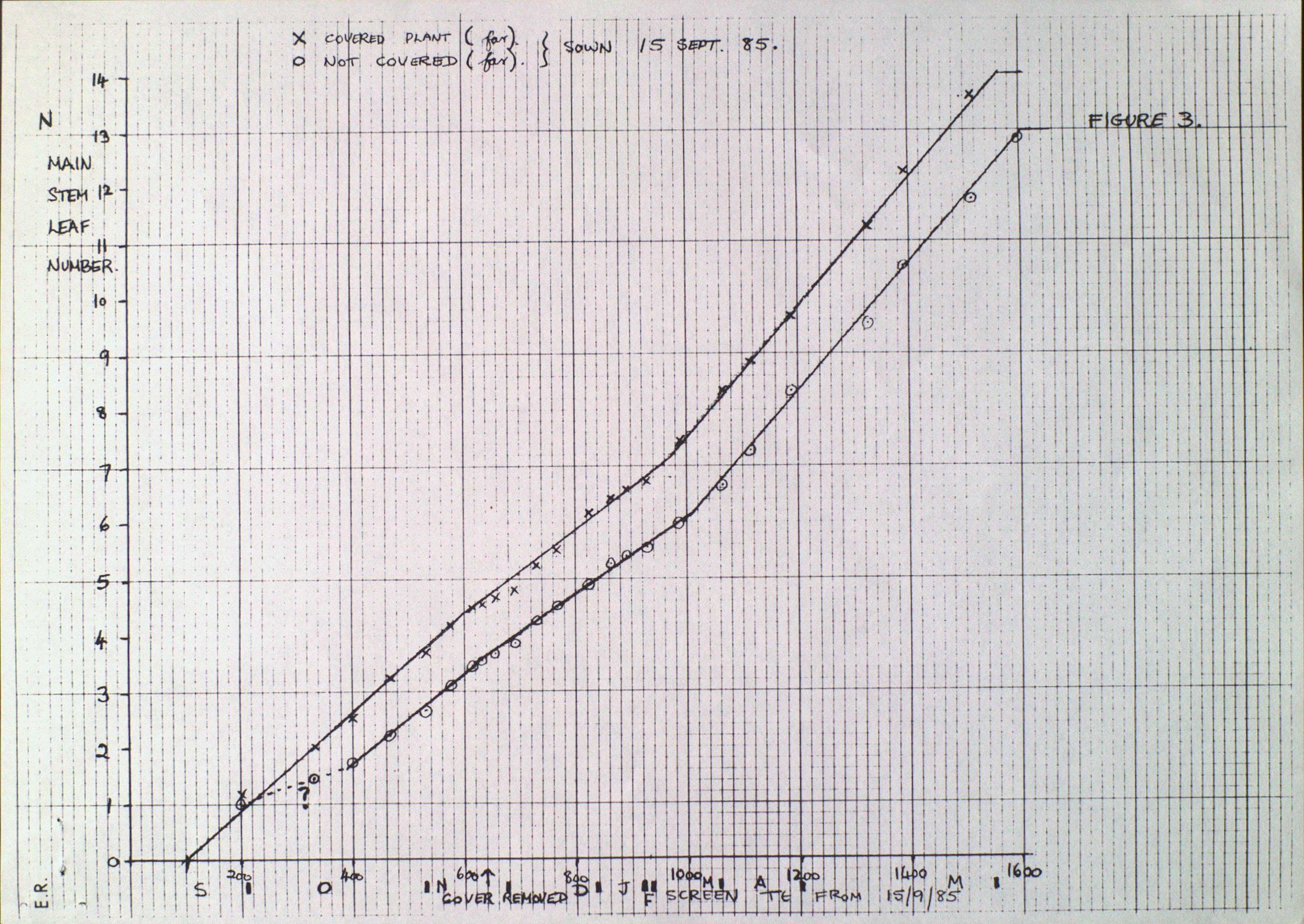
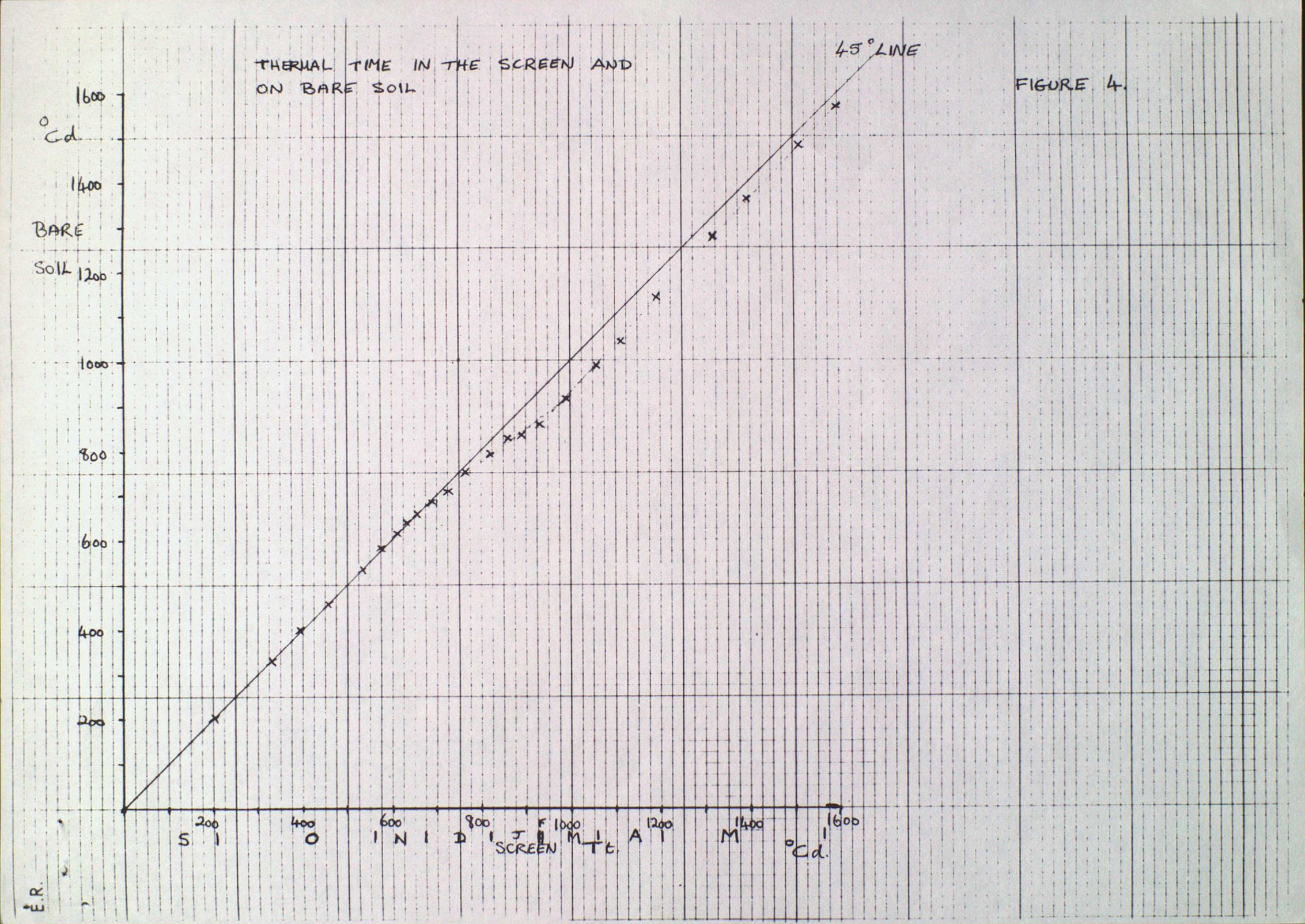

X COVERED PLANT (near)
O NOT COVERED. (near)
} SOWN 15 SEPT. 85
+ NOT COVERED
} SOWN 19 OCT 85
N.
MAIN
STEM
LEAF
NUMBER
15
14
12
10
8
6
4
2
0
0
S
200
O
400
N
600
D
800
J
1000
M
A
1200
1400
M
1600
J
COVER REMOVED
SCREEN TE FROM 15/9/85.
E.R.

FIGURE 2.


X COVERED PLANT (for).
O NOT COVERED (for).
SOWN 15 SEPT. 85.
FIGURE 3.
N
MAIN
STEM
LEAF
NUMBER.
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
S
200
O
400
N
600
800
D
J
1000
F
M
1200
A
1400
M
1600
COVER REMOVED
SCREEN
FROM 15/9/85
E.R.

THERMAL TIME IN THE SCREEN AND ON BARE SOIL

FIGURE 4.



E.R.